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PILE-UP DETECTION CIRCUIT

by

G. BERTOLINI, V. MANDL and G. MELANDRONE

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Joint Nuclear Research Center
Ispra Establishment - Italy
Materials Department
Nuclear Chemistry Service

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PILE-UP DETECTION CIRCUIT

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1. Introduction

Several pile-up detection circuits which reject two or more superposed or shortly distant events in a time range up to some microseconds have been described. Those circuits, particulary designed to handle high input rates have been used either to improve the resolution in nuclear spectroscopy[1-3]) or to eliminate certain chance coincidences due to piled-up pulses in fast-slow coincidence systems for life time measurements[4-7]).

In experiments involving moderate or low input rates (50–1000 pps) in which the best possible energy resolution is required such as could be performed with solid-state detectors or ionization chambers, the base line recovery time of the associated amplifiers is often long.

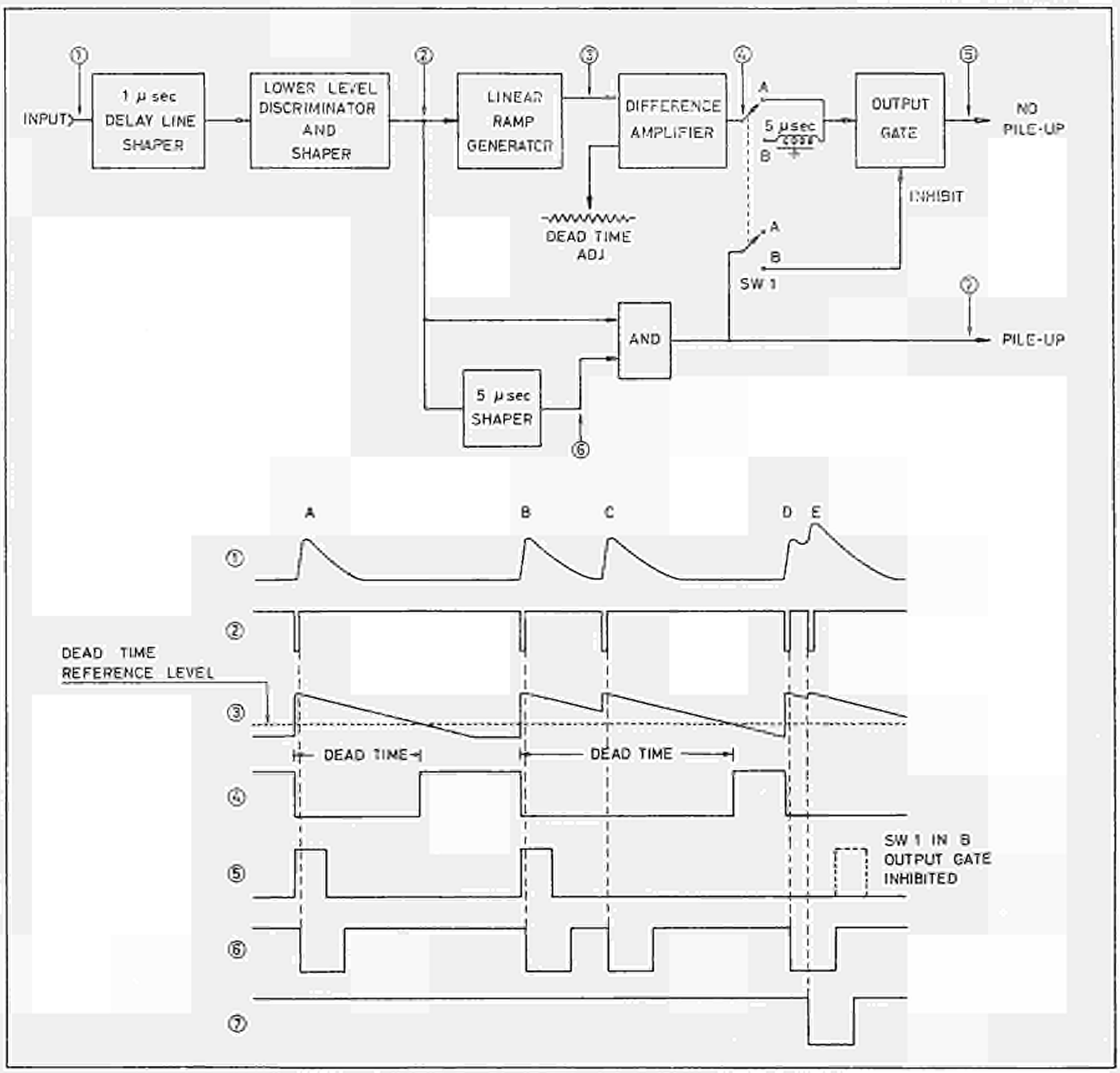

Fig. 1. The block diagram of the pile-up detector and its waveforms.

The amplified signals are followed by a tail, due to RC shaping, which may require many time constants to decrease to a negligible value[8]). To preserve as far as possible the intrinsic resolution of the detectors, beside using low noise amplifiers, it becomes than also necessary to introduce a dead time and to reject all those events following too closely the first one and which may be amplitude distorted by falling on its tail.

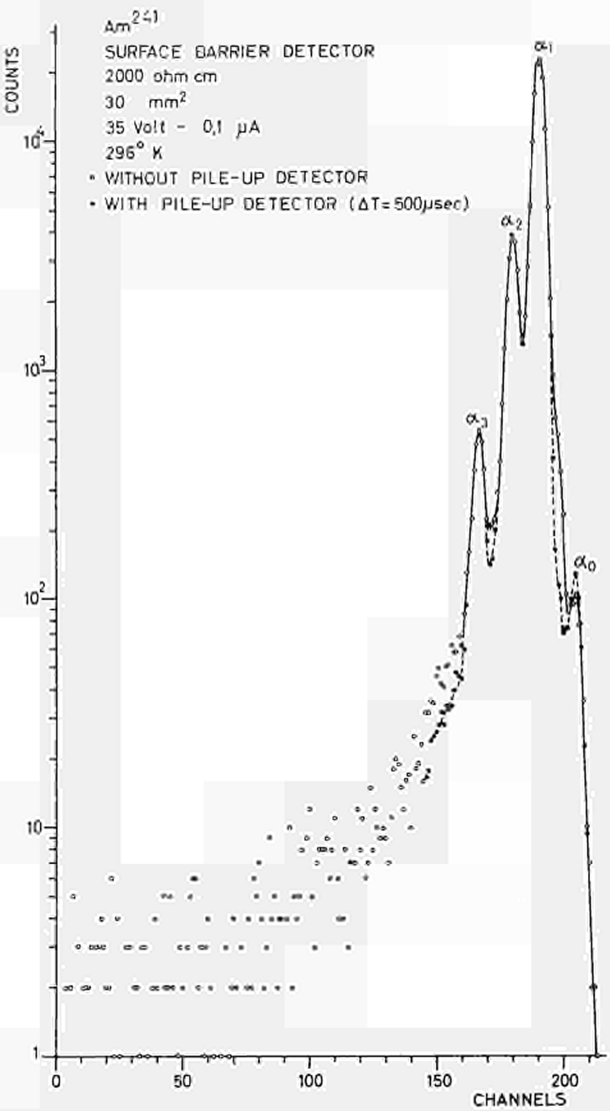

Fig. 2. Alpha spectra of Am^{241} with and without the pile-up detector.

The circuit we have built inhibits the analysis of those successive distorted pulses and rejects also the first one when pile-up occurs on its leading edge. A maximum dead time of 500 μsec can be introduced and all signals spaced by less than 5 μsec are canceled.

2. The description of the circuit and its performances

The block diagram of the circuit and its waveforms are reported in fig. 1. The input should be connected to an amplifier and one of the outputs to a coincidence or anticoincidence input of a pulse height analyzer. Any type of commercially available amplifier may be used in principle, but the input circuit of our unit was designed to match the Ortec Model 201 low noise amplifier.

The input signals are shaped and detected by a low level Schmitt discriminator. The linear ramp generator, which follows, is a capacitor charged to -20 V in its quiescent condition and discharged to ground each time an input signal triggers the discriminator. The capacitor is hold at ground level for 0.5 μsec, as long as lasts the output pulse from the discriminator and thereafter starts charging at constant current to -20 V in 500 μsec. The amplitude of the voltage ramp across the capacitor is monitored by a difference amplifier which has an adjustable reference and is switched from one to other state each time the ramp amplitude equals the reference voltage. This gives the dead time interval after each input signal where no analysis of other events is allowed. After the difference amplifier is switched back to its rest condition the next input signal triggers the output gate and generates a no pile-up output signal. This is iolustrated in fig. 1 where A and B are two input signals spaced by more than 500 μsec and analysed both, while C, which follows B to closely, is rejected.

Let us examine now the case of signals D and E which superimpose on their front edge. In order to reject such events SW1 should be switched in position B. The output signals from the difference amplifier are then delayed by 5 μsec before they trigger the output gate and the output from the amplifier to the input of the analyzer should be delayed also by the same time. When two input signals spaced less than 5 μsec are detected the "AND" circuit generates a pile-up output signal which inhibits the output gate so that both D and E signals are rejected. Analyzers equiped with at least 5 μsec anticoincidence facility may be controled directly from "pile-up" output with SW1 in position A so that signals from the amplifier to the analyzer need not to be delayed.

Alpha spectra of Am^{241} taken with and without the pile-up detector is reported in fig. 2. The source intensity was of about 130 pps, measured at the output of the amplifier and a 500 μsec dead time was introduced by the pile-up detector. An improvement of the peak to valley ratio between the fine structure alpha peaks due to the pile-up detector can be observed. A second spectra of Cr^{51} is shown in fig. 3. The consequence of the pile-up in this case is to deplete the photoelectric peak of gamma rays of Cr^{51} respect to the Compton distribution.

We wish to thank Mrs. Cappellani and Restelli for supplying us with solid state detectors.

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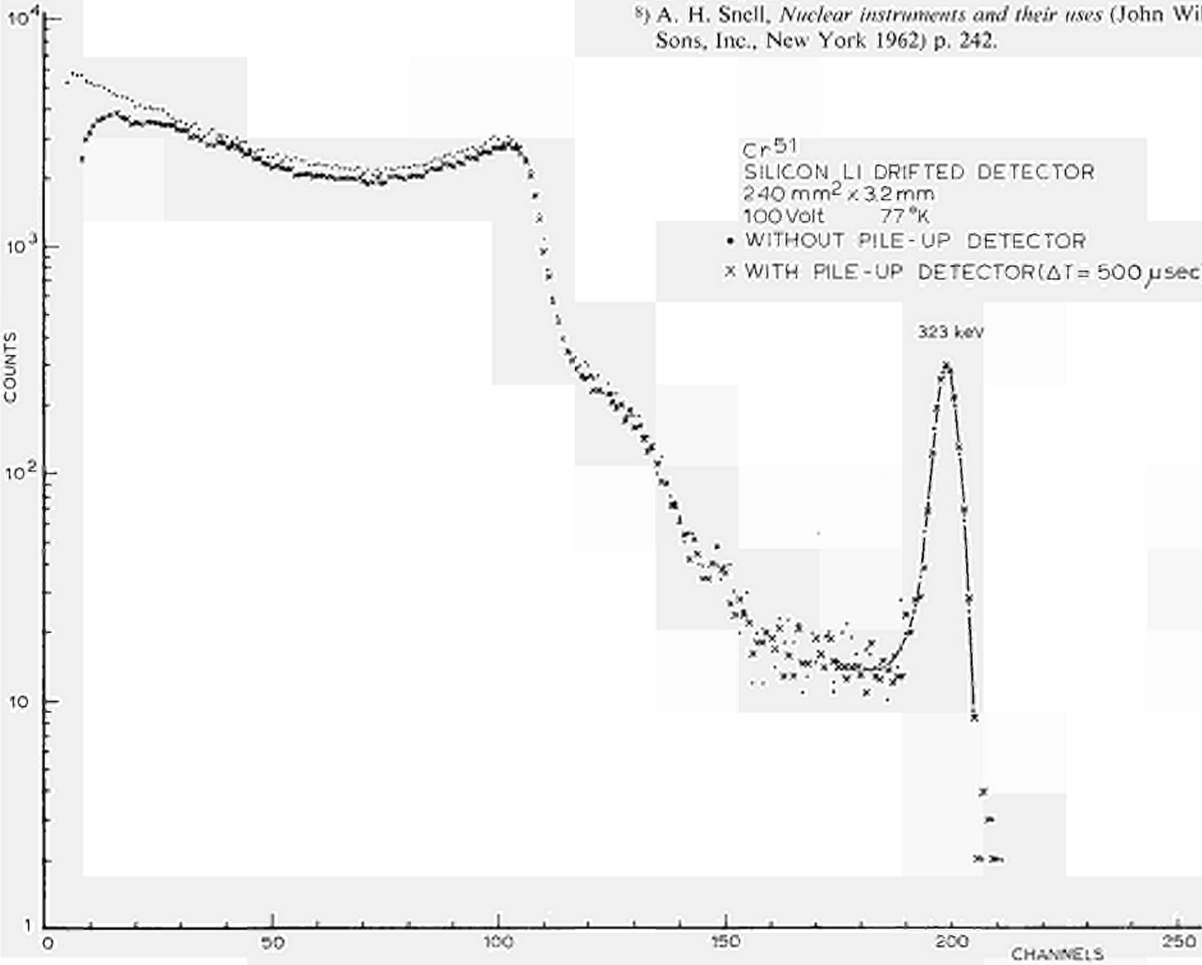

Fig. 3. Gamma spectra of Cr^{51} with and without the pile-up detector.

To disseminate knowledge is to disseminate prosperity — I mean general prosperity and not individual riches — and with prosperity disappears the greater part of the evil which is our heritage from darker times.

Alfred Nobel